Indoor positioning systems to prevent the COVID19 transmission in manufacturing environments

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Agenda

1. Current Scenario
2. Risk index
3. SHIELD4US architecture
4. Results & Discussion
5. Conclusions & further research

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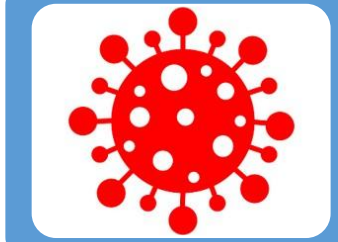
Current Scenario

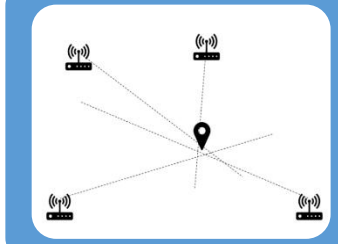


COVID-19 infections

- Millions of fatalities worldwide
- Major disruptions among several sectors

Industrial IoT sensors

- Digitalize the human factor
- Increase the consistency of the decision-making process



Indoor Positioning Systems

- Increase the visibility of manufacturing processes
- Widely adopted in safety management applications

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Contagion risk index

Personal risk of infection

i	Range of distance (m)	Exposure risk weight (r_i)
1	D<=0.4	1
2	0.4< D <=1.2	0.75
3	1.2< D <=1.7	0.5
4	1.7< D <=2	0.25

$$R_d^{g',g''} = \frac{\sum_{i=1}^{4}(w_{i,d}^{g',g''} * r_i) + \overline{RD_d^{g',g''}}}{2}$$

Cluster Analysis

j	Ranges of OL (m^2/p)	Exposure risk weight (s_j)
1	OL<1.7	1
2	1.7<= OL <2.1	0.8
3	2.1<= D <2.5	0.6
4	2.5<= OL <2.9	0.4
5	2.9<=OL<=3.1	0.2

$$R_m^c = \frac{\sum_{j=1}^{5}(w_{j,m}^c * s_j) + \overline{ROL_m^c}}{2}$$

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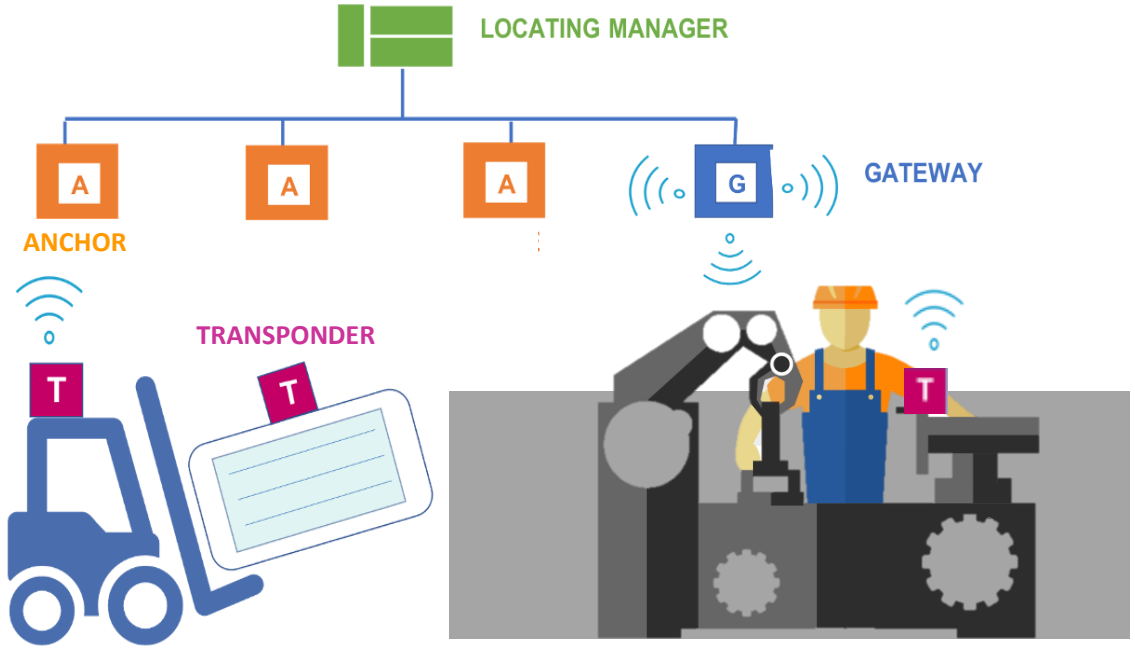
SHIELD4US architecture – HW part

The adopted indoor positioning system, based on radio-frequencies, is the **ultra-wideband** technology

1. **Anchors (ANs)**
2. **Transponders (TNs)**
3. **Gateways (GWs)**
4. **Locating manager (LM)**

Decawave DWM1001



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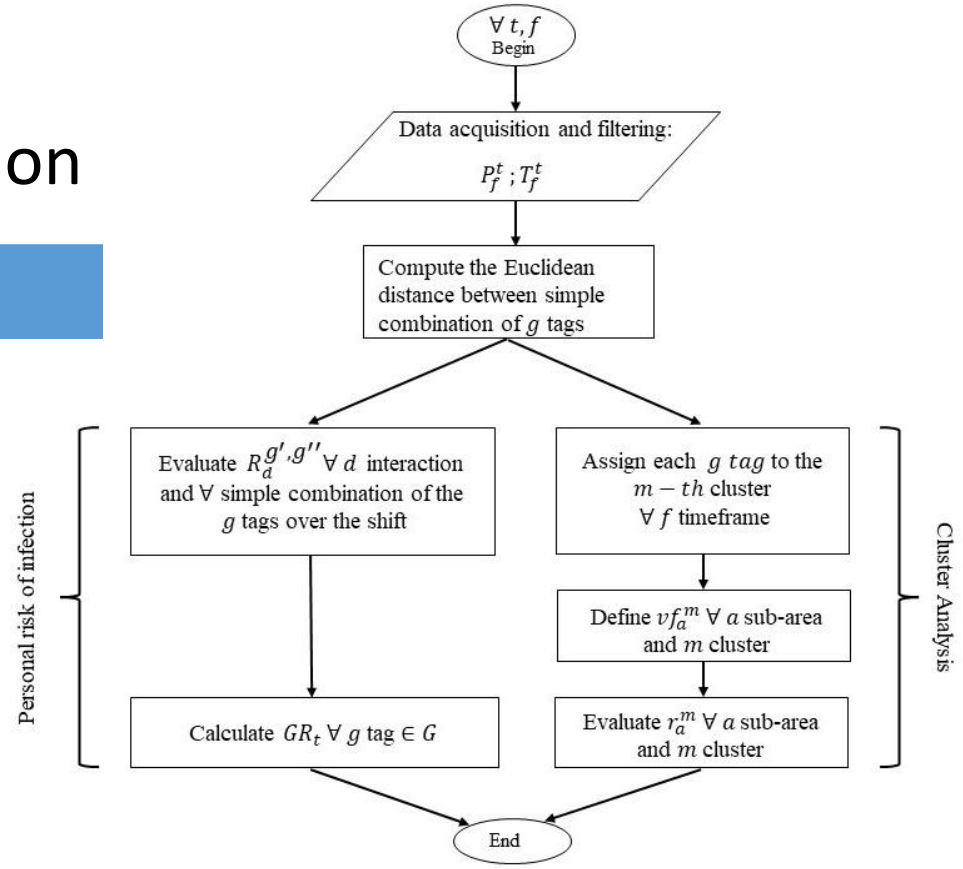
SHIELD4US architecture – SW part

Personal risk of infection

- Local risk of infection
- Global risk of infection



Cluster Analysis

- Visiting frequencies of each sub-area of the job shop
- Risk of infection for each sub-area of the job shop

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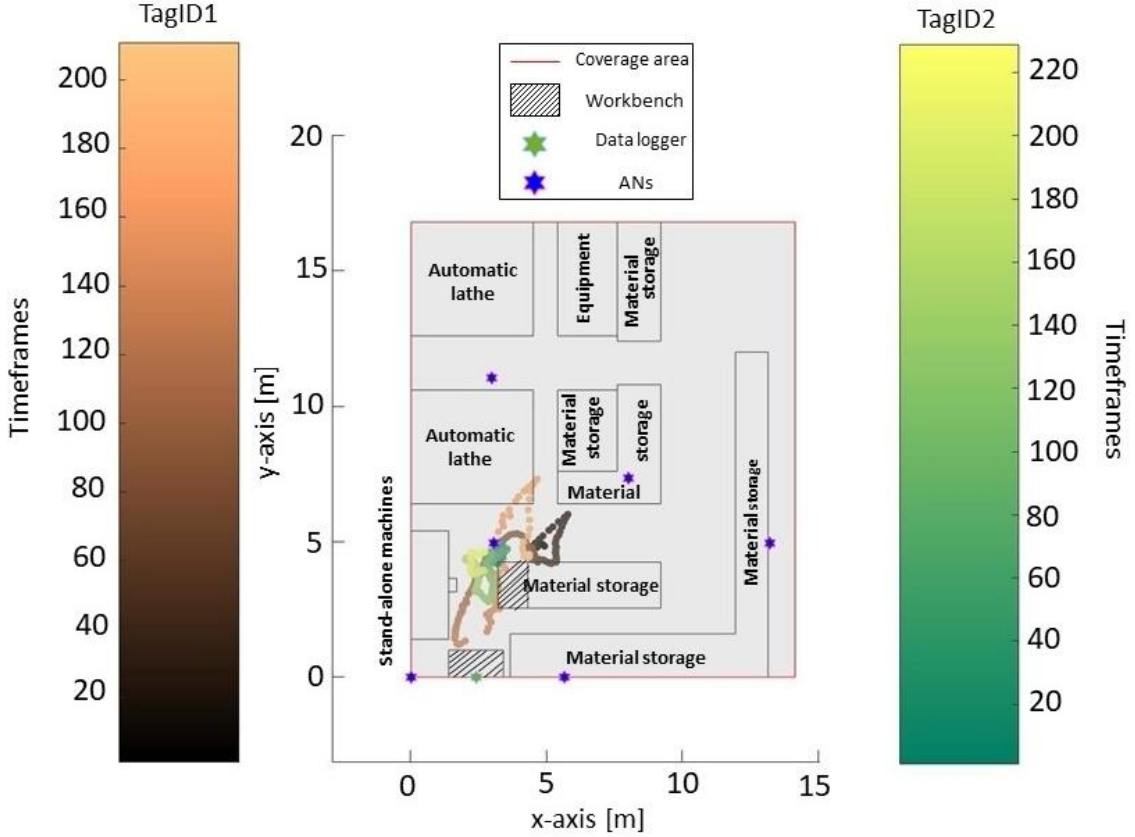
SHIELD4US architecture – Validation



Case Study: Italian manufacturer which performs manual mechanical processing for the automotive industry

$$\textbf{Contact duration} = T_d^{g',g''} = 25 \text{ seconds}$$

$$\textbf{Mean distance} = \overline{D_d^{g',g''}} = 1.8 \text{ meters}$$

i	Range of distance (m)	Exposure risk weight (e_i)	% time spent
1	D<=0.4	1	4%
2	0.4< D <=1.2	0.75	8%
3	1.2< D <=1.7	0.5	32%
4	1.7< D <=2	0.25	56%

$$R_d^{g',g''} = \frac{\sum_{i=1}^{4}(w_{i,d}^{g',g''} * r_i) + \overline{RD_d^{g',g''}}}{2} = 0.325$$

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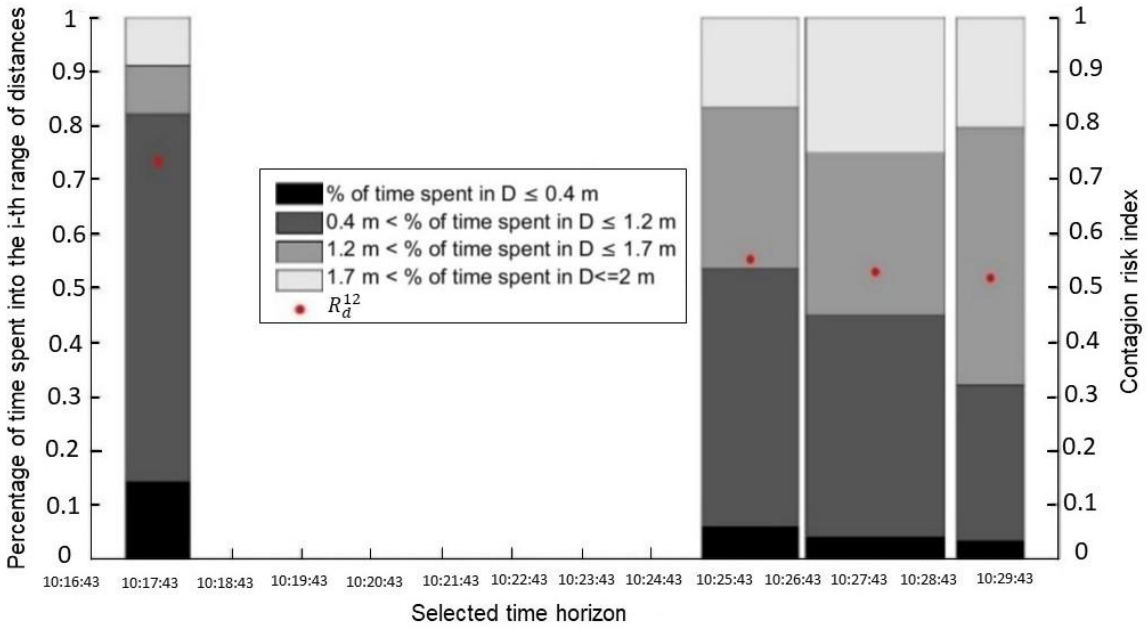
Results & Discussion

Dynamic values of $R_d^{1,2}$ from 10:15 to 10:30 on the 7th of December 2021



- $R_d^{1,2}$ values are affected by both $w_{i,d}^{1,2}$ and $T_d^{1,2}$
- $T_1^{1,2}$ = 55 sec and $T_3^{1,2}$ = 120 sec -> $R_1^{1,2} >>> R_3^{1,2}$

$$GR_1 = GR_2 = 0.526.$$

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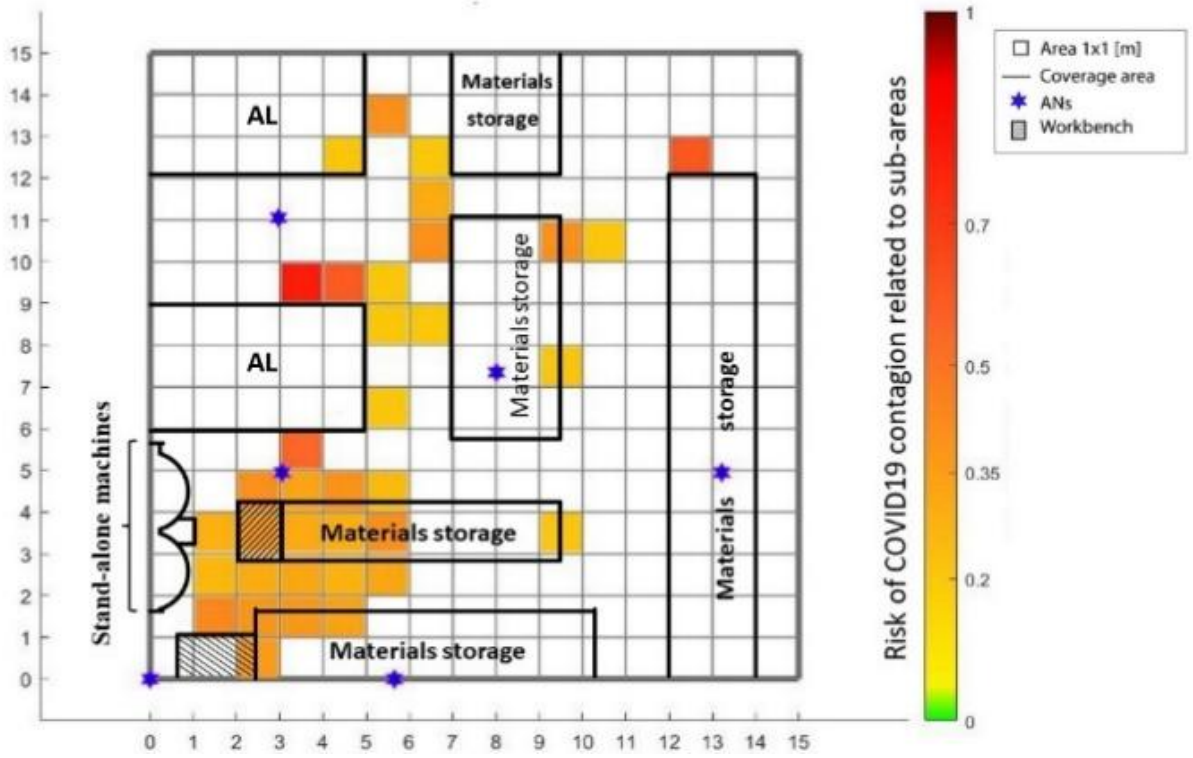
Results & Discussion

Risk of infection connected to sub-areas



Not necessarily the riskiest areas have high visiting frequency values

❖ vf_{147}^{1}=0.0018 and r_{147}^{1}=0.8 (next to AL)

In general, at the managerial level

1. High vf_a^m and high r_a^m : tailored re-layout processes

2. High r_a^m and low vf_a^m: visual management

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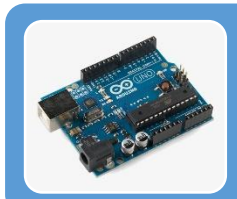
Conclusions & further research



Industrial IoT sensors

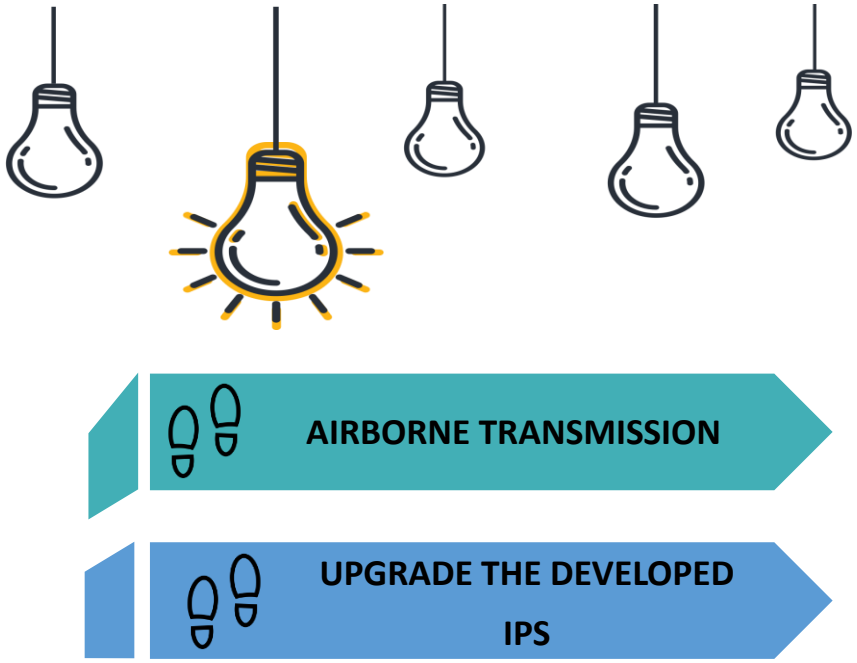
- Digitalize the human factor
- Safety-management

SHIELD4US digital architecture

- HW part: UWB-IPS
- SW part: safeguard the health of workers

Results

- Local and Global personal risk of infection
- Cluster analysis



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